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INVENTORS: OLE HENRY DORUM  
JOHN HANSON  
LAWRENCE M. KAPLAN

TITLE: SYSTEM AND METHOD FOR  
UPDATING A GEOGRAPHIC  
DATABASE USING SATELLITE  
IMAGERY

ATTORNEYS: Frank J. Kozak  
Lawrence M. Kaplan  
NAVIGATION TECHNOLOGIES  
CORPORATION  
Rosemont, Illinois 60018  
(847) 795-7000

1                                   SYSTEM AND METHOD FOR  
2                                   UPDATING A GEOGRAPHIC DATABASE  
3                                   USING SATELLITE IMAGERY  
4

5 BACKGROUND OF THE INVENTION

6           The present invention relates to a process for updating a geographic database and  
7 more particularly, the present invention relates to a process and system that uses satellite  
8 imagery for verifying and processing updates to a master copy of a geographic database.

9           Geographic databases have various uses. Geographic databases are used in  
10 in-vehicle navigation systems, personal computers, networked computing environments,  
11 and various other kinds of platforms, as well as on the Internet. Geographic databases are  
12 used with various kinds of applications to provide various functions including map  
13 display, route calculation, route guidance, truck fleet deployment, traffic control,  
14 electronic yellow pages, emergency services, and so on.

15           In order to provide these kinds of functions, a geographic database includes data  
16 that represent geographic features in a covered geographic region. Geographic databases  
17 include details about represented geographic features, such as the geographic coordinates  
18 of roads in a geographic region, speed limits along the road segments, locations of stop  
19 lights, turn restrictions at intersections of roads, address ranges, street names, and so on.  
20 Geographic databases may also include information about points of interest in covered  
21 regions. Points of interest may include restaurants, hotels, airports, gas stations,  
22 stadiums, police stations, and so on.

23           Collecting information for a geographic database is a significant task. According  
24 to one method, technicians (referred to herein as "researchers") are assigned the task of  
25 collecting data for a geographic database. Each researcher may physically travel  
26 throughout an assigned area and record information about observed geographic features.  
27 While in the field, the researcher may record the observed information by physically

1 writing on a printed copy of a map. For example, the researcher may write a description  
2 about an attribute of a geographic feature adjacent to the representation of the geographic  
3 feature on the map. Alternatively, the researcher may use a portable computer with a  
4 data collection program, as described in U.S. patent application Ser. No. 09/256,389 or  
5 Ser. No. 09/335,122, the entire disclosures of which are incorporated herein by reference.  
6 After the data are collected in the field, the researcher uses a computer program to enter  
7 data to a main (or master) copy of the geographic database. Working from the marked-up  
8 printed copy of the map, the researcher makes additions and/or changes to the data in the  
9 master geographic database to reflect the actual geographic features observed by the  
10 researcher while out in the field.

11 Beyond the initial effort involved in collecting data for a geographic database,  
12 there is a continuing need to update and check the data in the geographic database. Just  
13 like conventional printed maps, geographic databases become out-of-date. For example,  
14 new streets are constructed, street names change, traffic lights are installed, turn  
15 restrictions are added to existing roads, businesses change locations, road construction  
16 closes roads, detours are established, museum and restaurant hours change, etc. Thus,  
17 there exists a need to continue to collect updated information for a geographic database  
18 and then add the updated information to the geographic database.

19 One useful way to collect information for updating the geographic database is to  
20 obtain feedback from end users who have navigation systems or who use on-line sites  
21 that use copies of the geographic database to provide navigation-related features. These  
22 end users may discover that certain geographic data are not correct or are inaccurate. A  
23 geographic database developer can take advantage of this situation by providing a means  
24 by which end users can report the database errors or inaccuracies that they encounter.  
25 The error reporting system also provides an opportunity for generating good will between  
26 the geographic database developer and the end user

27 End users can report perceived errors by telephone or by the Internet. An  
28 example of an error reporting Internet site can be found at  
29 [www.navtech.com/database/data\\_driver.html](http://www.navtech.com/database/data_driver.html). In addition, error reporting systems are

1 disclosed in the copending patent applications Ser. Nos. 09/590,213 and 09/602,127, the  
2 entire disclosures of which are incorporated by reference herein.

3 After receiving a report from an end user about a perceived error or inaccuracy in  
4 the geographic database, the geographic database developer confirms that the error exists  
5 and then determines the correct information to be added to the master copy of the  
6 database. Sometimes the error perceived by the end user is not due to incorrect data in  
7 the geographic database, but instead is due to other factors, such as an error in the  
8 navigation system software. In some cases, a geographic database researcher may have  
9 to travel to the location of the perceived error to obtain the correct information. After  
10 confirming reports from end users, the geographic database researcher can make  
11 corrections to a master copy of the geographic database, which is then used to make new,  
12 updated versions of geographic databases for use in navigation systems or by on-line  
13 provider of navigation-related services.

14 Although the process works well, there still exists room for improvement. For  
15 example, it is relatively time-consuming and expensive to have a geographic database  
16 researcher travel out to the field to check each reported error. Accordingly, there exists a  
17 need for improved ways to handle the reporting of errors in the geographic database and  
18 the updating of the master copy of the geographic database.

## 19 20 SUMMARY OF THE INVENTION

21 To address these and other objectives, the present invention comprises a reporting  
22 program and system for updating a master copy of a geographic database. According to  
23 the method and system, reports are obtained that relate to data contained a geographic  
24 database. Satellite images of the geographic locations represented by the data in the  
25 reports are obtained. The satellite images are analyzed to confirm a need to make  
26 changes to the master copy of the geographic database based on the reports. After  
27 confirming the need to make the changes, the master copy of the geographic database is  
28 updated.

29

## 1 BRIEF DESCRIPTION OF THE DRAWINGS

2 Figure 1 is a block diagram of a first embodiment of a system for updating a  
3 geographic database.

4 Figure 2 is a flow chart of steps performed by the system of Figure 1.

5 Figure 3 illustrates the display screen of the of the geographic database  
6 researcher's workstation shown in Figure 1.

7

## 8 DETAILED DESCRIPTION OF THE 9 PRESENTLY PREFERRED EMBODIMENTS

10 Referring to Figure 1, a geographic database developer 100 operates an error  
11 reporting system 102. The error reporting system 102 enables end users 104 (e.g.,  
12 persons who obtain navigation-related or map-related services from navigation systems  
13 or from on-line providers of navigation services) to submit reports 106 relating to  
14 perceived errors that the end users discover in the geographic data used in the navigation-  
15 related or map-related services that are obtained from navigation systems or from on-line  
16 providers of navigation services. The reports 106 are used by the geographic database  
17 developer 100 to update a master copy 108 of the geographic database. After being  
18 updated, the master copy 108 of the geographic database is used to make derived  
19 geographic database products that are subsequently used in navigation systems or by  
20 on-line navigation services providers.

21 The error reporting system 102 may provide several different ways that the end  
22 users 104 can use to report errors. These ways include an on-line reporting program 112.  
23 The error reporting system 102 may include other ways to report errors, such as  
24 telephone-based error reporting and mail-based error reporting, described below.

25 Figure 1 shows the on-line error reporting program 112 operated by the  
26 geographic database developer 100. The on-line error reporting program 112 is located  
27 on a server 120 that is connected to a network 130, such as the Internet. End users 104  
28 operate computing platforms 140 to access the on-line error reporting program 112. The  
29 computing platforms 140 used by the end users 104 can be any type of device or system  
30 that is able to access the server 120 over the network 130. For example, the computing  
31 platforms 140 include personal computers 140(1) and vehicle navigation systems 140(2).

1 The computing platforms 140 may also include other types of computing devices or  
2 systems, such as personal digital assistants.

3 The computing platforms 140 used by the end users 104 include appropriate  
4 software to access the server 120 over the network 130. If an end user uses a personal  
5 computer 140(1) to access the server 120, the on-line reporting program 112 may be  
6 accessed using an Internet browser. Other communications software may also be used.

7 As stated above, the end users 104 access the on-line reporting program 112 in  
8 order to make reports about geographic data. In particular, the on-line reporting program  
9 112 may be used by the geographic database developer 100 to obtain reports from the end  
10 users 104 about perceived errors or inaccuracies in the geographic data used in the  
11 navigation systems of the end users or by on-line provider sites that are used by the end  
12 users to obtain navigation-related and map-related services. The perceived errors or  
13 inaccuracies can be of any type and may be encountered in various different ways. One  
14 of the ways that end users can encounter perceived errors or inaccuracies is during  
15 operation of in-vehicle navigation systems. For example, while being guided to follow a  
16 route to a destination, a navigation system may provide the end user with incorrect,  
17 inaccurate or confusing guidance. According to this example, the navigation system may  
18 advise the end user to 'TURN LEFT AT THE NEXT INTERSECTION' but the next  
19 intersection has a sign that prohibits left turns. According to another example, the  
20 navigation system may identify a street by a wrong name.

21 There are various reasons why a navigation system may provide incorrect,  
22 inaccurate or confusing guidance to an end user. One possible cause is that the  
23 geographic data used by the navigation system may be incorrect. The geographic data  
24 may be incorrect because of an error made when the data were being collected.  
25 Alternatively, the geographic data used by the navigation system may be incorrect  
26 because the physical feature represented by the geographic data changed since the time  
27 the geographic data used by the end user's system was collected.

28 Another possible cause for an end user receiving incorrect, inaccurate or  
29 confusing guidance from a navigation system can be an error in the software  
30 programming in the navigation system. In this case, the geographic data may be correct

1 but the end user receives incorrect, inaccurate or confusing guidance because the  
 2 software programming the navigation system does not use the geographic data properly.  
 3 For example, if the navigation system software determines a vehicle's position  
 4 incorrectly, a wrong street name may be provided thereby giving the end user the  
 5 impression that the geographic data are incorrect when in fact the navigation  
 6 programming caused the error.

7 Another reason why a navigation system may provide incorrect or confusing  
 8 guidance is that the geographic data used by the navigation system may not include the  
 9 attributes that are necessary to provide better instructions. For instance, the data  
 10 representing roads located in some geographic areas may not contain one-way street  
 11 information because this type of information has not yet been collected for those areas.  
 12 Alternatively, the software programming in the navigation system may not consider one-  
 13 way streets when providing driving directions.

14 As mentioned above, navigation-related and map-related services can also be  
 15 obtained from on-line navigation services providers. End users may access on-line  
 16 navigation services provider sites from their own personal computers or other platforms  
 17 or appliances to obtain navigation-related and map-related services. An end user using an  
 18 on-line navigation services provider site to obtain navigation-related and map-related  
 19 services may also encounter incorrect, inaccurate or confusing information. On-line  
 20 navigation services providers may use the same or similar geographic data and software  
 21 programming that are used in vehicle navigation systems. Therefore, on-line navigation  
 22 services provider sites may give incorrect, inaccurate or confusing navigation-related or  
 23 map-related information for the same reasons as explained above in connection with  
 24 vehicle navigation systems.

25 Regardless of the cause of a perceived error, the reporting program 112 provides a  
 26 means by which a report about the perceived error can be obtained from an end user. As  
 27 stated above, the end users 104 operate computing platforms 140 to access the reporting  
 28 program 112. The computing platform 140 used by an end user to access the reporting  
 29 program 112 may not necessarily be the same computing platform that the end user was  
 30 using when the navigation-related or map-related information containing the perceived

1 error was obtained. For example, an end user may perceive an error with the geographic  
 2 data used by his/her vehicle navigation system while driving in his/her vehicle, but then  
 3 accesses the reporting program later at home using his/her personal computer with  
 4 Internet access.

5 When the end user accesses the reporting program 112, the reporting program 110  
 6 presents the user with the option of making a report about a geographic database. When  
 7 the end user chooses this option, the reporting program 112 may request the end user to  
 8 identify the version of the geographic database to which the report pertains. After the end  
 9 user supplies information identifying the version of the database, the reporting program  
 10 112 presents the end user with a means to describe the error. The reporting program 112  
 11 may present the end user with a means to provide text input. The reporting program 112  
 12 may also provide the end user with a graphical interface so that the end user can indicate  
 13 a change graphically, e.g., by drawing on a map.

14 After the end user has completed the report, the reporting program 112 saves the  
 15 end user's input in a report file database 248. The data in the report file database 248 are  
 16 used in a geographic database updating process 300. The geographic database updating  
 17 process 300 is performed by the geographic database developer. According to one  
 18 embodiment, the process 300 is performed by a technician (i.e., a researcher) working for  
 19 the geographic database developer 100. The researcher works on a computer workstation  
 20 302 which may be any suitable networked computer hardware platform, such as a  
 21 personal computer, a terminal, etc.

22 Figure 2 show the steps performed by the geographic database updating process  
 23 300. The steps in Figure 2 may be performed by the researcher or alternatively, the steps  
 24 may be performed by a computer program with input from the researcher.

25 The geographic database updating process 300 receives the data from the reports  
 26 database 248 (Step 310). In one embodiment, a grouping step is performed (Step 312).  
 27 According to this embodiment, a relatively large number of separate reports are analyzed  
 28 to determine whether a significant number of them all relate to the same location. In a  
 29 preferred embodiment, the grouping step is performed by a software routine that is part of  
 30 the geographic database updating process. According to this embodiment, each report



1 106 identifies the geographic location of the reported error. The software routine  
 2 identifies all the reports that relate to the same, or substantially the same, location. If a  
 3 number of reports all relate to the same location, these reports may all relate to the same  
 4 problem and therefore may be processed together. Also, if a number of reports all relate  
 5 to the same area, they may be assigned a higher priority than reports that relate to isolated  
 6 areas.

7 According to another step of the process 300, the subject matter of each report (or  
 8 a grouping of more than one report) is analyzed to determine whether the type of error  
 9 being reported can be confirmed using satellite imagery (Step 314). Some types of  
 10 reported errors, such as addresses, street names, business names, or sign text, may not be  
 11 suitable for confirmation by satellite imagery. Other types of reported errors are suitable  
 12 for confirmation by satellite imagery. The types of reported errors that are suitable for  
 13 confirmation by satellite imagery include, but are not limited to, road geometry,  
 14 placement of roadway dividers, the number of roadway lanes, roadway lane widths,  
 15 roadway traffic direction restrictions (e.g., one-way streets), turn restrictions along a road,  
 16 whether a road is paved, road connectivity, the presence and locations of overpasses,  
 17 bridges, tunnels, ramps, turn lanes, frontage roads, railroad tracks, railroad terminals,  
 18 tollways, toll booths, road construction, train stations, ferries, border crossings, marinas,  
 19 certain types of points of interest (e.g., amusement parks, golf courses, and stadiums),  
 20 certain types of intersections (e.g., roundabouts), and possibly functional classes of roads.  
 21 In addition, satellite imagery can also be used to confirm errors about types of geographic  
 22 features, such as lakes, rivers, parks, and so on.

23 If a report relates to a type of error that is not suitable for confirmation by satellite  
 24 imagery, the report is designated for confirmation by field inspection. These reports are  
 25 forwarded to researchers who will travel out to the locations of the reported errors,  
 26 confirm the errors, determine the appropriate corrections to make to the master copy of  
 27 the geographic database, and then make the appropriate corrections.

28 After any grouping of reports occurs and any reports that are not suitable for  
 29 confirmation by satellite imagery are excluded, a satellite image of the location of each of

1 the reported errors is obtained (Step 320). According to one embodiment, the satellite  
2 images are high-resolution images that have an accuracy of approximately 1 meter.

3 An archive 322 of previously obtained satellite images is reviewed to determine  
4 whether a recently obtained satellite image of the area that contains the reported error is  
5 available (Step 324). The archive 322 may be maintained by the geographic database  
6 developer 100. The archive 322 may be stored on a server that is accessible to the  
7 developer's workstation (302 in Figure 1). In the archive 322, each satellite image is  
8 associated with a date. The date indicates when the satellite image was taken. The date  
9 of the satellite image is compared to an expiration schedule. The expiration schedule  
10 relates a type of error with an age of a satellite image. For some types of reported errors,  
11 the process 300 requires that the satellite image be relatively new, e.g., less than 30 days  
12 old, whereas for other types of reported errors, a relatively older image (e.g., up to 12  
13 months) will be suitable.

14 If a satellite image is available from the database developer's archive 322 and  
15 meets the requirements for being recent enough, the satellite image 326 is provided to the  
16 process 300 (Step 328). If the database developer's archive 322 does not have a satellite  
17 image that contains the area of the reported error or if the satellite image in the archive  
18 322 is too old, a new satellite image is obtained from a satellite image firm 330 (Step  
19 332). (The satellite image firm may be a commercial firm, such as Earthwatch.) The  
20 researcher may need to specify the area for the new satellite image or the area may be  
21 automatically extracted from the report by the software included in the process 300. The  
22 satellite image firm 330 may have the image taken. Alternatively, the satellite image firm  
23 330 may be able to provide the image from its own archive if the image is new enough to  
24 meet the requirements of the database developer's expiration schedule. The satellite  
25 image firm may deliver the image to the researcher electronically, e.g., on-line via a  
26 network, or may send an electronic or analog image by mail.

27 The process 300 obtains data 338 from the master copy 108 that relate to the area  
28 of the reported error (Step 340). The data 338 from the master copy 108 are presented to  
29 the database developer researcher, along with the satellite image 326 and the report  
30 (Step 344). The data 338 from the master copy 108, the satellite image 326 and the

1 report may be presented to the researcher on a display screen of the workstation (302 in  
2 Figure 1) used by the researcher to perform the updating process 300.

3 The data 338, the satellite image 326 and the report may be presented to the  
4 researcher in various different ways. In one embodiment, the satellite image 326 is  
5 presented to the researcher as a background and the data 338 from the master copy of the  
6 geographic database 108 are overlaid on the image 326. The report may be displayed in a  
7 window on the display screen. By overlaying the data 338 from the master copy of the  
8 database over the satellite image 326, the researcher can determine whether the data 338  
9 from the master copy of the geographic database correctly represent the actual geographic  
10 features. The information from the report can be used to identify the perceived error and  
11 also to indicate what the end user perceived the error to be.

12 Figure 3 shows an example of a display screen 350 of the researcher's  
13 workstation 302. Shown as a background on the display screen 350 is the satellite image  
14 326. The satellite image 326 shows portions of several roads. Overlaid on the satellite  
15 image 326 are representations of several road segments 354. The representations of road  
16 segments 354 are formed using the data 338 from the master copy of the geographic  
17 database.

18 To assist the researcher, the position of the reported error may be located at the  
19 center of the display screen 350. The position of the reported error may be highlighted or  
20 a square, circle, or other shape may be generated about the position of the reported error.  
21 Alternatively, the corresponding latitude and longitude may be displayed as the  
22 researcher moves a cursor over the image so that the researcher can find the position of  
23 the reported error.

24 In an alternative embodiment, instead of showing the representations of  
25 geographic features from the data in the geographic database as an overlay on the satellite  
26 image, the representations of geographic features from the data in the geographic  
27 database can be shown side-by-side with the satellite image on the display screen of the  
28 researcher's workstation.

29 Referring again to Figure 2, based on the satellite image 326, and possibly the  
30 report 106, the researcher inputs a correction to the master copy of the geographic

1 database (Step 360). The input may relate to road geometry, i.e., that a road is not where  
 2 the database represents it to be. The input may relate to lane dividers, number of  
 3 roadway lanes, roadway lane widths, roadway traffic direction restrictions (e.g., one-way  
 4 streets), turn restrictions along a road, whether a road is paved, or numerous other  
 5 changes. In addition, satellite imagery can also be used to confirm changes about other  
 6 types of geographic features, such as lakes, rivers, parks, or recreational areas (including  
 7 golf courses, stadiums, and so on). Based on the input from the researcher, the master  
 8 copy of the geographic database 108 is updated (Step 370). The updated master copy of  
 9 the geographic is then used to make updated versions of derived geographic database  
 10 products that are used in end users' navigation systems and by on-line providers of  
 11 navigation-related and map-related services.

12 If a new satellite image was obtained (instead of using an image from the database  
 13 developer's archive), a copy of the new satellite image is stored in the archive for  
 14 possible future use.

#### 16 Alternatives

17 In the embodiment described above, satellite images were obtained, as needed, to  
 18 confirm reported errors received from end users. In an alternative embodiment, a  
 19 complete collection of satellite images can be obtained for the entire coverage area of the  
 20 master copy of the geographic database (or portions thereof). These images can be stored  
 21 in an archive maintained by the geographic database developer. Then, when an image is  
 22 needed to confirm a reported error, the image can be obtained immediately from the  
 23 archive. Some or all the images stored in the archive can be periodically updated.

24 In one embodiment, a grid is defined that overlays the entire coverage area of the  
 25 master copy of the geographic database. Then, when a satellite image is needed, the  
 26 satellite image is obtained so that it corresponds to a cell of the grid. In this manner,  
 27 satellite images are not obtained that substantially overlap each other, thereby making the  
 28 process of obtaining satellite images more efficient.

29 As mentioned above, the geographic database developer operates a reporting  
 30 system 102 that enables end users to make reports about perceived errors in the

1 geographic data. In the embodiment described above, the reporting system 102 includes  
2 an on-line reporting program (112 in Figure 1) that enables end users to make reports via  
3 a network using their computer platforms. In an alternative embodiment, end users can  
4 make reports about geographic data by means other than over a network. For example,  
5 an end user may make a report by telephone. According to this alternative, the end user  
6 uses a telephone to report an error to a human operator. The human operator obtains the  
7 necessary information from the end user and submits a report which is then handled in a  
8 manner similar to the reports that are submitted using the on-line reporting program (102  
9 in Figure 1), described above. Alternatively, the end user uses a telephone to report an  
10 error to a telephone reporting program that prompts the end user to make a report using  
11 the keys of the telephone. According to another alternative, the end user uses a telephone  
12 to dictate a description of the error on a recording device (such as an answering machine)  
13 that is operated by the database developer. An employee of the database developer then  
14 listens to the message and generates a report that is handled in a manner similar to the  
15 reports that are submitted using the on-line reporting program.

16 In another alternative, the end user may submit a report by mail. A report  
17 submitted by mail may be transcribed into electronic form and processed in the manner  
18 described above.

19  
20 It is intended that the foregoing detailed description be regarded as illustrative  
21 rather than limiting and that it is understood that the following claims including all  
22 equivalents are intended to define the scope of the invention.